AMENDMENTS TO THE SPECIFICATION

Please amend the title to read:

NONLINEARITY ERROR CORRECTING METHOD AND PHASE ANGLE MEASURING METHOD FOR DISPLACEMENT MEASUREMENT IN TWO-~~FREQENCY~~ FREQUENCY LASER INTERFEROMETER AND DISPLACEMENT MEASUREMENT SYSTEM USING THE SAME

Page 1, please amend paragraph 1 to read:

The present invention relates to a phase angle measuring method and a nonlinearity error correcting method in a two-frequency laser interferometer used for displacement measurement and a system using the same, and more particularly, to a phase angle measuring method and a nonlinearity error correcting method in a two-frequency laser interferometer for displacement measurement and system using the same, which can drastically improve accuracy in displacement measurement by adjusting offsets, amplitudes and phase between two output signals from a phase demodulator used for phase angle measurement in a two-frequency laser interferometer.

Page 1, paragraph 2, please amend paragraph 2 to read:

FIG.1 illustrates a typical configuration of an optical system and ~~a~~ phase measuring electronics in a two-frequency laser interferometer for displacement measurement.

Page 2, please amend paragraph 5 to read:

Here, electromagnetic fields Er_1 and Er_2 of two orthogonally linear-polarized laser beams are expressed ~~as~~ by the following Equations 1 and 2:

Please amend paragraph 14, bridging pages 2 and 3 to read:

The transmitted beam at the beamsplitter 2 is completely separated at a polarizing beamsplitter 3 so that each beam has its own frequency and polarization direction, provided that ~~a~~ frequency mixing is absent. These two beams are reflected by a fixed mirror 4a and a moving mirror 4b usually employing a corner cube prism, and recombined on the polarizing beamsplitter again.

Page 3, please amend paragraph 15 to read:

Here, the laser beams cover paths of different length L_1 and L_2. ~~The~~ L_1 signifies a distance from the polarizing beamsplitter 3 to the fixed mirror 4a, and ~~the~~ L_2 signifies a distance from the polarizing beamsplitter 3 to the moving mirror 4b. The laser beams pass through a polarizer 5b and then an interference signal of the two laser beams is detected in a photodetector 6b.

Page 4, please amend paragraph 27 to read:

where n indicates a refractive index of a medium, generally air, through which the laser beam passes and L is a relative displacement(L_1-L_2) between the moving mirror 4b relative to the fixed mirror 4a. The above Equations 3 and 6 show sinusoidal signals having different phases and beat frequencies which are a frequency difference $\Delta\omega$ of the two beams.

Page 4, please amend paragraph 29 to read:

Initially, a 90° phase mixing electronics includes a 90° phase shifter 7 and two mixers 8a and 8b. The 90° phase mixing part receives two beat signals I_r and I_m and outputs signals proportional to <u>the</u> sine and cosine of the phase angle θ. Here, the signals of sine and cosine having 90° phase difference are used to measure magnitude and direction of the displacement of the moving mirror.

Page 5. please amend paragraph 30 to read:

~~Function~~ The function of the 90° phase mixing electronics will be explained in detail as follows. Two beat signals I_r and I_m, signals corresponding to the beat frequency of $\Delta\omega_2$ are passed by high-pass filters. The reference beat signal I_r from the photodetector 6a is divided into an existing reference beat signal and a reference beat signal having a 90° phase difference by the 90° phase shifter 7. The measurement beat signal I_m from the photodetector 6b is divided into two signals having the same phases. The four reference and measuring beat signals are multiplied by the two mixers 8a and 8b and output into such two signals as the following Equations 8 and 9:

Page 6, please amend paragraph 40 to read:

Referring to the signals I_X and I_Y of Equations 10 and 11, there is a 90° phase difference between the two signals as shown in FIG.2. Perfect sine and cosine signals with no offsets and the same amplitudes are obtained. Further, ~~A~~ a Lissajou figure drawn by corresponding the above signals I_X and I_Y to X and Y axes of an orthogonal coordinate creates a perfect circle as shown in FIG.3. In case of such nonlinear-free signals expressed by Equations 10 and 11, the phase angle θ can be easily calculated from the following Equation 12:

Page 7, please amend paragraph 45 to read:

These errors result in nonlinear relationship between the phase angle θ measured and the relative displacement between the two mirrors. ~~It~~ This means that the calculated displacement using Equation 12 will have ~~the~~ a nonlinearity error which has ~~a~~ periodic characteristics.

Page 7, please amend paragraph 46 to read:

Accordingly, the conventional method using only the 90° phase mixing technique in the two-frequency laser interferometer does not consider the nonlinearity error caused by the frequency mixing, thereby resulting in an error in the displacement measurement.

Please amend paragraph 48, bridging pages 7 and 8, to read:

An object of the present invention is to provide a nonlinearity error correcting method and a phase angle measuring method and system using the same which can drastically improve accuracy of displacement measurement in a two-frequency laser interferometer by measuring and correcting offsets, amplitudes and phases of two sine and cosine output signals from ~~a~~ 90° phase mixing electronics used for measuring a phase angle in the two-frequency laser interferometer.

Please amend paragraph 50, bridging pages 8 and 9 to read:

To achieve these objects and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, there is provided a phase angle measuring method for displacement measurement in a two-frequency laser interferometer, which uses a two-frequency laser, ~~a~~ 90° phase mixing electronics and ~~a~~ phase angle calculating electronics and performs the steps of mixing a reference signal I_r produced ~~due to~~ <u>by</u> an interference of the two frequency laser beams and a 90° phase shifted reference signal with a measurement signal I_m produced ~~due to~~ <u>by</u> an interference of two frequency-laser beams reflected on the fixed and moving mirrors, filtering high frequency terms to produce two output signals I_x and I_y, and obtaining a phase angle θ for displacement measurement, the phase angle measuring method comprising the steps of obtaining the output signals output from the 90° phase mixing electronics, and ellipse parameters including amplitudes a and b, offsets I_{x0} and I_{y0} and difference from phase-quadrature ϕ included in two output signals and applying the same to the following Equation to calculate the phase angle θ:

Page 13, please amend paragraph 60 to read:

FIG.2 illustrates an typical view of two output signals I_x and I_y, perfect sine and cosine signals, from ~~a~~ 90° phase mixing electronics when a nonlinearity error is absent in an optical system and ~~an~~ electronics, wherein there are no offsets, <u>the</u> amplitudes are <u>the</u> same, and a phase difference

of the two output signals I_x and I_y is 90°;

Page 13, please amend paragraph 61 to read:

FIG.3 illustrates a Lissajou figure of the two output signals I_x and I_y of FIG.2, wherein the figure is a perfect circle when ~~any~~ nonlinearity error is absent;

Page 23, please amend paragraph 108 to read:

As mentioned above, the fact that when a frequency mixing is present, the sine and cosine signals I_x and I_y, which are outputs from the mixers 8a and 8b, are distorted by the nonlinearity error and the phase angle calculation by Equation 12 can not provide an exact phase is a main idea of the present invention.

Page 23, please amend paragraph 109 to read:

In a real system, due to unequal gains, offsets of electronic circuit and lack of quadrature of 90° phase shifter 7 in displacement measuring electronics, the output signals from the mixers 8a and 8b can be represented ~~as~~ by the following Equations 20 and 21:

Page 23, please amend paragraph 115 to read:

This means that the output signals I_x and I_y output from the mixers 8a and 8b are not signals having exact sine and cosine. As illustrated in FIG.6, amplitudes are different, offsets are not zero, and a difference from the phase-quadrature is not zero. In a more clear explanation, the Lissajou figure of FIG.7 is distorted and has an ellipse ~~circle~~.

Please amend paragraph 116 to read:

However, if we clearly know the ellipse parameters, such as amplitudes a and b, offsets I_{xo} and I_{yo} and a difference from the phase-quadrature ϕ in the above Equations 20 and 21, a corrected phase angle θ can be determined by inducing the following Equation 22 from Equations 20 and 21:

Page 23, please amend paragraph 119 to read:

The phase angle calculated by Equation 22 ~~doesn't~~ <u>does not</u> contain the nonlinearity error caused from the frequency mixing. Thus, the exact displacement L of the moving mirror 4b can be obtained from the phase angle θ calculated by Equation 22.

Please amend paragraph 120 to read:

When the two-frequency laser interferometer 100 is nonlinear-free (amplitudes a and b are same, offsets I_{xo} and I_{yo} and <u>the</u> difference from the phase-quadrature ϕ are zero), Equation 22 is same as Equation 12, thereby having the same phase value as when there is no frequency mixing.